Proposed Nomenclature for the Immunoglobulins of the Domesticated Bovidae

Cattle (Bos taurus)
Sheep (Ovis aries)
Goats (Capra hircus)

BOVIDAE IgG

The bulk of the immunoglobulins occurring in the serum and lacteal secretions of the three named species possess antigenic determinants (1,28) and physicochemical characteristics (1,2,6,7,8,19,21,32,39) in common with the IgG class as defined in the human (5). Heterogeneity of these immunoglobulins has been demonstrated in all three species (1,2,6,8,16,17,18,21,32,35,36). Clear-cut evidence for two distinct subclasses is available for all three species (1, 8,14,29,35) although a third has been claimed for the sheep (13). The IgG1 and IgG2 subclasses of cattle are described below.

IgG1

Bovine IgG1 of the serum and colostrum differs from IgG2 in that it migrates faster toward the anode in a basic agar-gel electrophoretic field (1,14,31) or slower toward the cathode in acrylamide gel at pH 4.5 (8). It is the predominant immunoglobulin of the lacteal secretions (1,6,10,26, 31) and is antigenically distinct from IgG2. Antisera produced against IgG1 in heterologous species detect antigenic determinon the γ-chains of IgG1 which are not detected on the γ-chains of IgG2 (29).

These differences presumably reside in the Fc fragment in all three species although this has been demonstrated only in the sheep (14).

IgG2

Bovine IgG2 constitutes less than one-half of the total IgG found in the serum of most cattle (26,33), carries a greater net positive charge than IgG1 and differs antigenically from IgG1 in its γ-chains (29). Bovine IgG2 carries the A1/A2 allotypes on its Fc fragment which are absent on the γ-chains of IgG1 (3,4).

The IgG subclasses described here for cattle can be shown to be antigenically homologous to the IgG1 and IgG2 of sheep (14) and presumably of the goat. Additional IgG subclasses would be based upon the demonstration of specific γ-chain antigenic determinants distinct from those of IgG1 and IgG2 and which occur on molecules present in all normal members of the species.

BOVIDAE IgA

Bovine, ovine and caprine IgA are defined by their cross reactions with anti-human a-chain antisera (26,27,41). Bovine IgA has physicochemical (6,7,8,25,37,41) distributional (10,12,22,26,37) and synthetic characteristics (10,11,26,27,41) similar to those described for human IgA (40) with exception of the mammary gland and its secretions (10,22,26,27). Bovine IgA has been shown to be homologous to that of the goat and sheep (34). Designation of sub-

Published with the permission of the Journal of Dairy Science.

classes of this immunoglobulin would be based upon demonstrated antigenic differences shown to reside in the a-chains of molecules which occur in all normal members of the particular species.

Bovidae IgM

Bovine IgM is described by its cross reactions with anti-human μ-chain antisera (28). Ovine and caprine IgM are defined by their cross reactions with anti-bovine μ-chain antisera (34). The IgM described for these species has physicochemical characteristics similar to human IgM (6,7,28, 32). Recent studies (30) indicate that bovine IgM is larger than human IgM and that a 7S form of IgM occurs in adult bovine serum (8). Designation of subclasses of this immunoglobulin would be based upon demonstrated antigenic differences shown to reside in μ-chains of molecules which occur in all normal members of the particular species.

Bovidae Free Secretory Component (FSC)

Bovine glycoprotein-a (15) and FSC (23, 25) are identical as defined by their antigenic cross reactivity (24) and by their partial common antigenicity with bovine secretory IgA (7,8,9,25,26). The demonstration of sequence homology and/or immunological cross reactions between this protein and human secretory component (SC) will be necessary to establish whether they are homologous. Bovine glycoprotein-a and human SC have identical patterns of immunofluorescence in the intestinal lumen of the respective species (42). The FSCs of goat and sheep should be shown to be homologous to that of cattle on the basis of antigenic cross reactivity.

Light Polypeptide Chains

All classes and subclasses of bovine immunoglobulins share common antigenic determinants on their light polypeptide chains (7, 8). The light chains of cattle share antigenic determinants with those of sheep (20) and presumably the goat and are predominantly of the lambda type (20, 38). Recently, a lambda type Bence-Jones protein from cattle has been characterized and purified (38).

ACKNOWLEDGMENTS

This nomenclature scheme was drawn up by the following investigators who attended the Symposium on the Bovine Immune System held at College Park, Maryland, on November 18-20, 1970. In addition, we thank Drs. T. B. Tomasi, Jr. (State University of New York at Buffalo) and Alan E. Pierce (Commonwealth Scientific and Industrial Research Organization, Melbourne, Australia) for their suggestions.

Ole Aalund
Dennis Blakeslee
John E. Butler
J. Robert Duncan
M. James Freeman
Robert Jenness
J. Michael Kehoe
Jean-Pierre Mach
Jan Rapacz
Jean-Pierre Vaerman
Alex J. Winter

REFERENCES

1. **AALUND, O.** Heterogeneity of ruminant immunoglobulins. Thesis. Royal Vet. and Agricultural Univ., Munksgaard, Copenhagen, Denmark. 1968.
2. **AALUND, O., J. W. OSEBOLD and F. A. MURPHY.** Isolation and characterization of ovine gamma globulins. Archs Biochem. Biophys. **109**: 142-149. 1965.
3. **BLAKESLEE, D., J. RAPACZ and J. E. BUTLER.** Bovine immunoglobulin allotypes. Symposium: Bovine Immune System. J. Dairy Sci. **54**:1319-1320. 1971.
4. **BLAKESLEE, D., J. E. BUTLER and W. H. STONE.** Serum antigens of cattle II. Immunogenetics of two immunoglobulin allotypes in cattle. J. Immun. **107**: 227-235. 1971.
5. Bulletin World Health Organization. Nomenclature for human immunoglobulins. **30**: 447-450. 1964. (Reprinted in Immunochemistry **1**: 145-149.)
6. **BUTLER, J. E.** Bovine immunoglobulins: A review. J. Dairy Sci. **52**: 1895-1909. 1969.
7. **BUTLER, J. E.** Physicochemical and immunochemical studies on bovine IgA and glycoprotein-a. Biochim. biophys. Acta. In Press, 1971.
8. **BUTLER, J. E. and C. F. MAXWELL.** The preparation of the bovine immunoglobulins and free secretory component and their specific antisera. J. Dairy Sci. In press. 1971.
9. **BUTLER, J. E., E. J. COULSON and M. L. GROVES.** The identification of glycoprotein-a as a probable fragment of bovine IgA. Fedn Proc. **27**: 617. 1968. (Abstr.)
10. **BUTLER, J. E., C. F. MAXWELL, C. S. PIERCE, C. A. ROCK, R. ASOFSKY and C. A. KIDDY.** The distribution and studies on the synthesis of bovine IgA. Proc. Soc. exp. Biol. Med. In press, 1971.
11. **BUTLER, J. E., C. A. KIDDY, C. F. MAXWELL, M. B. HYLTON and R. ASOFSKY.** Synthesis of immunoglobulins by various tissues of the cow. Symposium: Bovine Immune System. J. Dairy Sci. **54**: 1323-1324. 1971.

12. **BUTLER, J. E., C. A. KIDDY, C. S. PIERCE and C. A. ROCK.** Quantitative changes associated with calving in levels of bovine immunoglobulins in selected body fluids. I. Changes in the levels of IgA, IgG1 and total protein. (Manuscript submitted 1971).
13. **CURTAIN, C. C.** A new immunoglobulin subclass in sheep. Immunology **16**: 373-380. 1969.
14. **FEINSTEIN, A. and M. J. HOBART.** Structural relationship and complement fixing activity of sheep and other ruminant immunoglobulin G subclasses. Nature, Lond. **223**: 951-953. 1969.
15. **GROVES, M. L. and W. G. GORDON.** Isolation of a new glycoprotein-a and a yG-globulin from individual cow milks. Biochem., Easton **6**: 2388-2394. 1967.
16. **HARRISON, E. T. and M. G. MADGE.** Isolation and characterization of sheep y1- and y2-immunoglobulins and their polypeptide chains. Biochim. biophys. Acta. **147**: 52-59. 1967.
17. **HEIMER, R., D. W. JONES and P. H. MAURER.** The immunoglobulins of sheep colostrum. Biochem., Easton **8**: 3937-3943. 1969.
18. **HEIMER, R., L. G. CLARK and P. H. MAURER.** Immunoglobulins of sheep. Archs Biochem. Biophys. **131**: 9-17. 1969.
19. **HESS, E. L. and H. F. DEUTSCH.** Biophysical studies of blood plasma proteins. VIII. Separations and properties of the y-globulins of the sera of normal cows. J. Am. Chem. Soc. **70**: 84-88. 1948.
20. **HOOD, L., W. R. GRAY, B. G. SANDERS and W. J DREYER.** Light polypeptide chain evolution. Cold Spring Harbor Symposium **32**: 133-146. 1967.
21. **KICKHOFEN, B., D. K. HAMMER and D. SCHELL.** Isolation and characterization of yG type immunoglobulins from bovine serum and colostrum. Hoppe-Seyler's Z. Physiol. Chem. **349**: 1755-1773. 1968.
22. **KIDDY, C. A., C. F. MAXWELL, C. A. ROCK, C. S. PIERCE and J. E. BUTLER.** Changes in levels of immunoglobulins in serum and other body fluids immediately before and after parturition. Symposium: ovine Immune System. J. Dairy Sci. **54**:1325-1327. 1927.
23. **MACH, J. P.** In vitro combination of human and bovine free secretory component with IgA of various species. Nature, Lond. **228**: 1278-1282. 1971.
24. **MACH, J. P. and J. E. BUTLER.** Antigenic identity of bovine free secretory component and glycoprotein-a. Personal communication, 1971.
25. **MACH, J. P., J. J. PAHUD and H. ISLIKER.** IgA with "secretory piece" in bovine colostrum and saliva. Nature, Lond. **223**: 952-954. 1969.
26. **MACH, J. P. and J. J. PAHUD.** Secretory IgA, a major immunoglobulin in most bovine external secretions. J. Immun. **106**: 552-563. 1971.
27. **MACH, J. P.** The bovine secretory immune system. Symposium: Bovine Immune System. J. Dairy Sci. **54**: 1327. 1971.
28. **MEHTA, P. D. and T. B. TOMASI, Jr.** Comparative studies of mammalian immunoglobulins. Fedn Proc. **28**: 820. 1969. (Abstr.)
29. **MILSTEIN, C. P. and A. FEINSTEIN.** Comparative studies of two types of bovine immunoglobulin G heavy chains. Biochem., Easton **107**: 559-564. 1968.
30. **MUKKUR, T. K. S. and A. FROESE.** Isolation and characterization of IgM from bovine colostral whey. Immunochemistry **8**: 257-264. 1971.
31. **MURPHY, F. A., O. AALUND, J. W. OSEBOLD and E. J. CARROLL.** Gamma globulins of bovine lacteal secretions. Archs Biochem. Biophys. **108**: 230-239. 1964.
32. **MURPHY, F. A., J. W. OSEBOLD and O. AALUND.** Physical heterogeneity of bovine yM and yG globulins. Archs Biochem. Biophys. **112**: 126-136. 1965.
33. **NANSEN, P.** Metabolism of bovine immunoglobulin-G. Thesis. Royal Vet. and Agricultural Univ., Munksgaard, Copenhagen, Denmark. 1970.
34. **PAHUD, J. J. and J. P. MACH.** Identification of secretory IgA, free secretory piece and serum IgA in the ovine and caprine species. Immunochemistry **7**: 679-686. 1970.
35. **PAN, I. C., A. M. KAPLAN, R. L. MORTER and M. J. FREEMAN.** Spectrum of ovine immunoglobulins. Proc. Soc. exp. Biol. Med. **129**: 867-870. 1968.
36. **PIERCE, A. E. and A. FEINSTEIN.** Biophysical and immunological studies on bovine immune globulins with evidence for selective transport within the mammary gland from maternal plasma to colostrum. Immunology **8**: 106-123. 1965.
37. **PORTER, P. and D. E. NOAKES.** Immunoglobulin IgA in bovine serum and external secretions. Biochim. biophys. Acta **214**: 107-116. 1970.
38. **RODKEY, L. S. and A. T. KIMMELL.** Characterization and purification of a bovine Bence-Jones protein. Immunochemistry. In press, 1971.
39. **SMITH, E. L.** The immune proteins of bovine colostrum and plasma. J. biol. Chem. **164**: 345-358. 1946.
40. **TOMASI, T. B., Jr. and J. BIENENSTOCK.** Secretory immunoglobulins. Adv. Immunol. **9**: 1-96. 1968.
41. **VAERMAN, J. P.** Studies on IgA immunoglobulins in man and animals. Thesis. Univ. Catholique de Louvain, Sintal, Belgium. 1970.
42. **YURCHAK, A. M., J. E. BUTLER and T. B. TOMASI, Jr.** Fluorescent localization of immunoglobulins in the tissues of the cow. Symposium: Bovine Immune System. J. Dairy Sci. **54**:1324-1325. 1971.

(Reprinted from CANADIAN JOURNAL OF COMPARATIVE MEDICINE, Vol. 35, No. 4, October, 1971 — 360 Bronson Ave., Ottawa 4, Ontario)